APPENDIX E

Technical Memorandum #5 – Criticality Assessment

Kimley-Horn
and Associates, Inc.

HIGHFILL
Infrastructure Engineering, P.C.

P.O. Box 33068
Raleigh, North Carolina 27636-3068
Tel 919-677-2000 Fax 919-653-5847

1150 SE Maynard Road, Suite 250
Cary, North Carolina 27511
Tel 919-481-4342 Fax 919-882-9762

TECHNICAL MEMORANDUM #5

To:	Mr. Frank Styers Superintendent of Capital Projects City of Wilmington 305 Chestnut, Street Wilmington, NC 28401	**Copies:**	Tom Ames, TWB Hugh Caldwell, City Dan Check, City Gary McSmith, NHC Greg Thompson, NHC Ken Vogt, City Michael Vukelich, TWB
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From:	Tyler W. Highfill, PE J. Chris Ford, PE	**HIE Proj. No.:**	KHA0601
Subject:	Technical Memorandum #5 – Criticality Assessment Northeast Interceptor Evaluation		

1 Background

The Northeast Interceptor (NEI) is the critical link in conveying wastewater flow from portions of Wilmington and New Hanover County and all of Wrightsville Beach to the Southside WWTP. The NEI includes the largest and 3rd largest wastewater pump stations in the collection system and includes approximately 49,000 LF of force main. The complexity, size, expansiveness, and proximity to important water resources lend itself to a criticality assessment to determine which elements of the system are most important to maintain reliable wastewater service.

In parallel with the criticality assessment, the NEI is also undergoing a capacity analysis, system operations evaluation, and pipeline condition assessment. This technical memorandum summarizes the process used to rank the most critical elements of the NEI, identifies deficiencies, and makes recommendations for improvements.

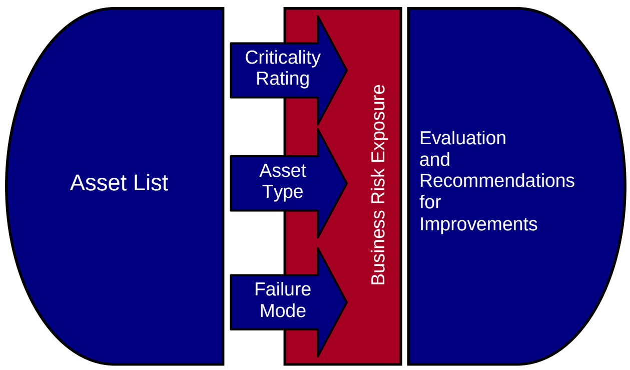
2 Methodology

In order to understand the individual importance of each element or sub-system of the NEI, a list of all the major assets was developed. Each asset was reviewed with the NEI team members and a criticality rating was assigned. In addition, each asset was assigned a “type” category and a “most likely mode of failure” category. Every asset has a certain life span and will fail at some point. As such, business risk level criteria were established to reliably meet the operational goals. Asset criticality, asset type category, and asset failure modes were reviewed in light of the acceptable business risk exposure criteria to establish recommendations and prioritize improvements to deficient items.

3 Criticality Assessment

The criticality assessment is a logical process that starts with an inventory of key assets; rates each asset according to criticality, asset type, and failure mode; compares the rankings to the accepted business risk exposure; and culminates with recommendations for improved reliability. Figure TM 5.1 shows the interrelated nature of the six step process used on this project.

Figure TM 5.1 – Criticality Evaluation Model



3.1 Asset List

The asset list was developed by performing a take-off of the original system construction record drawings prepared by Henry Von Oesen (December 1983) supplemented with field investigations of station modifications by subsequent projects. During a Criticality Workshop, assets were reviewed by a group of NEI team members and revisions were made to get a current and thorough major asset list as shown in Table TM 5.1.

Minor assets such as lights, sinks, electrical junction boxes, etc. were not included in the major asset list because they are ancillary to pump station operation. These minor assets should be considered if an asset management program is implemented, but they are not part of the major assets that were assessed.

Common system components were grouped into one asset. As a general rule, when an asset would be purchased as a whole component, that component was defined as an asset. For example, a pump asset includes the volute, impeller, shaft, bearings, pump support stand, etc. The motors, however, were treated as separate assets due to their size. When a group of assets was determined to operate in a similar critical manner, assets were sometimes grouped to simplify discussions.

3.2 Criticality Rating

A criticality workshop was held to bring together NEI team members from operations level staff to management level staff to gain a full understanding of the overall objectives of reliable operation, a full understanding of how the system components work, and to identify known weak links. Appendix TM 5-A includes the Power Point presentation that was delivered to kick-off the workshop.

The following definitions were reviewed and developed in the workshop:

- Key asset: piece (or group) of equipment, structure, or material important to the proper operation of the NEI system.
- Proper operation: capable of meeting the required level of service.
- Required level of service (LOS): performance that meets the requirements of its stakeholders, customers and regulators while doing so at a cost tolerable to the customers.
    - Primary Performance Goal: Safely move water delivered to the NEI system to the Southside WWTP.
    - Secondary Performance Goal: Control odors from the NEI system and control corrosion within the NEI system.

Based on the asset list and the definitions above, two groups worked independently in the workshop to rank the major assets. One group was assigned the pump station 34 (PS 34) assets and about half of the pipeline assets. The second group was assigned pump station 35 (PS 35) assets and the remaining pipeline assets. The groups assigned each asset to a critically matrix like the one below:

Figure TM 5.2 – Criticality Matrix

		CONSEQUENCE OF IMMEDIATE FAILURE		
		LOW (1)	MOD. (2)	HIGH (3)
IMPORTANCE FOR PROPER OPERATION	LOW (A)			
	MOD. (B)			
	HIGH (C)			

For consistency in ranking assets on the Criticality Matrix, the group developed the following clarifications of the consequence and importance ratings:

- Low Consequence (1): Little to no effect on meeting the primary level-of-performance goal.
- Moderate Consequence (2): Potential effect on meeting the primary level-of-performance goal, but there is some time to respond and resolve the failure.
- High Consequence (3): Nearly immediate failure of the primary level-of-performance goal (i.e. a likely wastewater spill).

- Low Importance (A): Little to no lost capacity and no effect on meeting the primary level-of-service goal.

- Moderate Importance (B): Reduced system capacity or loss of automatic operations at PS 35.

- High Importance (C): System capacity is significantly reduced or failure causes immediate damage to other structures or equipment or a loss of automatic operations at PS 34. Due to the complexity of PS 34 and the relatively small wetwell, the group thought that loss of automatic operations at PS 34 was of the up-most importance.

Once each group had completed their criticality rankings, each asset was posted by its ranking on a wall-size criticality matrix. Since assets at PS 34 operate in a similar mode to many assets at PS 35, we compared the rankings of each group. When the rankings were different, we either agreed that both were equally critical and agreed on a ranking or determined why they were different and agreed on different rankings for each.

The resulting criticality rankings are shown graphically in Table TM 5.2.

3.3 Asset Type Categories

Since static systems such as buildings, structures, and fencing have a long expected life and will typically show signs of failure prior to complete loss, an “asset type” category was included in the asset list to assist with prioritization. Although a condition assessment of the assets was not included, the assets were assigned one of the following categories:

Category I: Static or structural component, no known deficiencies

Category II: Mechanical and control asset, no known deficiencies

Category III: Static or structural component, known deficiencies

Category IV: Mechanical and control asset, known deficiencies

3.4 Failure Mode

All assets will reach a point of failure at sometime. Some assets have very long lives while others have short lives. Understanding how an asset is most likely to fail, provides valuable information toward predicting and preventing failures.

There are five accepted types of failure categories. Each category is listed below along with a brief explanation of the category and how the failure is typically avoided or resolved:

1. Capacity Limited: Assets in this category fail because they cannot serve the needed capacity. *Resolving this mode of failure typically requires a system re-design.*

2. Level of Service: Assets in this category fail because something in the system has changed making the design conditions invalid. *Resolving this mode of failure typically requires a system re-design.*

3. Consumptive Mortality: Assets in this category fail because of degradation over time, often due to wear-and-tear or corrosion. *Resolving this mode of failure typically requires repair or rehabilitation.* When cost effective, proper maintenance can increase the life of equipment and materials delaying the consumptive mortality; however, some equipment and materials are not cost effective to perform regular maintenance on and are operated in a run-to-failure mode.

4. Efficiency Limited: Assets in this category are considered to have failed when the efficiency becomes intolerable or when the standard performance of efficiency for the asset increases to the point that replacement of the asset will provide long-term savings. *Resolving this mode of failure typically requires asset replacement.*

5. Willful or Un-willful Intent: Assets in this category fail because they incur fatal operator error, natural disaster, or vandalism. *Resolving this mode of failure is not always possible, but accepted levels of risk can be used to incorporate appropriate safeguards.* Some safeguards may include constructing and maintaining structures to current building codes, installing and monitoring security detection devices, and training operators on proper operation of and maneuverability around equipment.

Each of the assets has been assigned to a failure mode category based on its role in the NEI system as shown in Table TM 5.3.

3.5 Business Risk Exposure

Through feedback from the NEI Technical Review Committee meetings and the criticality assessment workshop, business risk exposure (BRE) criteria have been established as follows:

- Critical (consequence categories 2 and 3) mechanical and control systems should be properly sized and provided with on-line redundant systems in place to prevent wastewater from spilling onto the ground. On-line back-up systems should be kept in reliable operating condition.

- On-line monitoring systems should be in place to detect and annunciate failures of all critical (consequence categories 2 and 3) mechanical and control systems.

- Static systems (such as buildings, pipelines, valves, and fencing) do not require redundant systems. The team recognizes that although pipelines and valves are static, they stretch across vast lands and are subject to the dynamics of fluid flow and corrosion. Pipelines should be properly sized for projected flows. When feasible, multiple connected pipelines will improve the Staff's capabilities for event management.

- Systems for odor and corrosion control should be capable of reliable, automatic operation. These items do not have an immediate consequence to the NEI primary performance goal upon failure so on-line redundancy is not required.

- The BRE evaluation uses the likely failure mode category for each asset to determine how each asset will likely fail. For "consumptive mortality" rated assets, the operational focus is to maximize asset life through effective maintenance. "Willful or un-willful intent" rated assets should have protective measures in place. The remaining categories (capacity limited, level of service, and efficiency limited) will drive asset replacement in due time that avoids violating the BRE minimum criteria.

All assets should be inspected periodically and maintained regularly. Category 1 (low consequence) mechanical and control system assets should have parts and materials available in a nearby supply house and a plan of action in place to deal with asset failures.

3.6 Critical Asset Evaluation and Recommendations

The discussions below follow the asset listing shown in Table TM 5.3 which includes the assets sorted first by their criticality ranking and then by asset type category making them priority ranked from highest to lowest priority. Assets that are ranked the same and related in their service are discussed as an asset group. The discussion of assets and recommendations for improvement are based on the criticality rating, asset type, and most likely asset failure mode.

3.6.1 "Consequence Factor 3" Asset Evaluation

Table TM 5.4 outlines the asset evaluations for this consequence category.

3.6.2 "Consequence Factor 2" Asset Evaluation

Table TM 5.5 outlines the asset evaluations for this consequence category.

3.6.3 "Consequence Factor 1" Asset Evaluation

Proper operation of the assets in this category is important to meet the NEI secondary level of service goals and for operational flexibility; however, assets in this category have a low consequence of failure on the primary performance goal. As such, there is some time to react to failures and make necessary repairs. Extended asset outages could cause damage to higher consequence factor assets if not repaired promptly. As such, an "asset failure plan of action" should be prepared for each of these items. The plan should document the following:

- Equipment data necessary to order repair parts or replacement equipment
- Local parts and/or equipment supplier contact information
- Estimated lead time to procure and install parts and equipment (if repair timeline exceeds BRE criteria, procure and store critical parts)
- Means and tools to install materials or equipment

In addition, use good periodic inspection and monitoring to help anticipate problem before they become major or affect other systems.

4 Conclusions and Recommendations

The alternatives and options discussed above should be evaluated with the NEI partners' overall goals and objectives and coupled with the results of the field pipeline testing, reliability assessment, and operational analysis to assure proper implementation.

Observations and recommendations of the criticality assessment should be implemented as follows:

1. Define service area and future design capacity
2. Determine pipeline solution
3. Evaluate key assets in relation to future operating conditions and implement recommendations listed in Tables TM 5.4 and TM 5.5 to address deficient critical assets.
4. Prepare the Asset Failure Action Plan for "Category Factor 1" assets.
5. Continue proper operation and regular maintenance on all equipment not programmed as run-to-failure equipment.
6. Inspect assets and monitor key asset parameters. Proactively repair problematic elements to reduce likelihood of failure.

Attachments:

Tables

TM 5.1 - NEI Key asset List (Stored by Asset ID Number)
TM 5.2 - Graphical Representation of Key Asset Criticality Ratings
TM 5.3 - NEI Ranked Asset List
TM 5.4 - "Consequence Factor 3" Asset Evaluation Summary
TM 5.5 - "Consequence Factor 2" Asset Evaluation Summary

Appendices

TM 5-A - Criticality Workshop Introduction

TABLES

Table TM 5.1 - NEI Key Asset List (Sorted by ID number)
NEI Criticality Assessment
HIEPC Project No KHA0601

May 30, 2006
By: TWH

ID	Asset	ID	Asset
35-1	County Precast Vault	34-1	County FM Vault
35-2	Influent Barscreen Structure	34-2	Influent Barscreen Structure
35-3	Barscreen Unit 1	34-3	Barscreen Unit 1
35-4	Manual Bar Rack	34-4	Barscreen Unit 2
35-5	Screenings Conveyor	34-5	Screenings Conveyor
35-6	Pump Station Structure	34-6	Pump Station Structure
35-7	Odor Control Filter 1	34-7	Odor Control Filter 1
35-8	Odor Control Filter 2	34-8	Odor Control Filter 2
35-9	Odor Control Blower	34-9	Odor Control Blower
35-10	Odor Control Duct	34-10	Odor Control Duct
35-11	Corrosion Control Chem Storage	34-11	Corrosion Control Chem Storage
35-12	Corrosion Control Feed Pump	34-12	Corrosion Control Feed Pump
35-13	Corrosion Control Feed Piping	34-13	Corrosion Control Feed Piping
35-14	Pump #1 Suction PV	34-14	Pump #1 Suction PV
35-15	Pump #1 Suction Piping	34-15	Pump #1 Suction Piping
35-16	Pump #1 (2500 gpm)	34-16	Pump #1 (3500 gpm)
35-17	Motor #1 (60 hp)	34-17	Motor #1 (100 hp)
35-18	Pump #1 Discharge Piping	34-18	Pump #1 Discharge Piping
35-19	Pump #1 Discharge CV	34-19	Pump #1 Discharge CV
35-20	Pump #1 Discharge PV	34-20	Pump #1 Discharge PV
35-21	Pump #1 Elect. Drive	34-21	Pump #1 Elect. Load Cell
35-22	Pump #2 Suction PV	34-22	Pump #2 Suction PV
35-23	Pump #2 Suction Piping	34-23	Pump #2 Suction Piping
35-24	Pump #2 (2500 gpm)	34-24	Pump #2 (3500 gpm)
35-25	Motor #2 (50 hp)	34-25	Motor #2 (100 hp)
35-26	Pump #2 Discharge Piping	34-26	Pump #2 Discharge Piping
35-27	Pump #2 Discharge CV	34-27	Pump #2 Discharge CV
35-28	Pump #2 Discharge PV	34-28	Pump #2 Discharge PV
35-29	Pump #2 Elect. Load Cell	34-29	Pump #2 Elect. Load Cell
35-30	Pump #3 Suction PV	34-30	Pump #3 Suction PV
35-31	Pump #3 Suction Piping	34-31	Pump #3 Suction Piping
35-32	Pump #3 (4300 gpm)	34-32	Pump #3 (6000 gpm)
35-33	Motor #3 (125 hp)	34-33	Motor #3 (300 hp)
35-34	Pump #3 Discharge Piping	34-34	Pump #3 Discharge Piping
35-35	Pump #3 Discharge CV	34-35	Pump #3 Discharge CV
35-36	Pump #3 Discharge PV	34-36	Pump #3 Discharge PV
35-37	Pump #3 Elect. Load Cell	34-37	Pump #3 Elect. Load Cell
35-38	Pump #4 Suction PV	34-38	Pump #4 Suction PV
35-39	Pump #4 Suction Piping	34-39	Pump #4 Suction Piping
35-40	Pump #4 (4100 gpm)	34-40	Pump #4 (6600 gpm)
35-41	Motor #4 (150 hp)	34-41	Motor #4 (400 hp)
35-42	Pump #4 Discharge Piping	34-42	Pump #4 Discharge Piping
35-43	Pump #4 Discharge CV	34-43	Pump #4 Discharge CV
35-44	Pump #4 Discharge PV	34-44	Pump #4 Discharge PV
35-45	Pump #4 Elect. Soft Start	34-45	Pump #4 Elect. Drive
35-46	PS Common Header Piping	34-46	PS Common Header Piping
35-47	PS Common Header PV	34-47	PS Common Header PV
35-48	Elect. Service Entrance	34-48	Elect. Service Entrance
35-49	Elect. Main Circuit Panel	34-49	Elect. Main Circuit Panel
35-50	Automatic Transfer Switch	34-50	Automatic Transfer Switch
35-51	Generator (200 kW)	34-51	Generator (450 kW)
35-52	Generator Fuel Tank & Accessories	34-52	Generator Fuel Tank & Accessories
35-53	Pump Control Panel (Island Automation)	34-53	Pump Control Panel (Island Automation)
35-54	Pump Bubbler System	34-54	Pump Bubbler System
35-55	High-High Level Float Control System	34-55	High-High Level Float Control System

ID	Asset	ID	Asset
35-56	SCADA Panel	34-56	SCADA Panel
35-57	Drywell Sump Pump	34-57	Drywell Sump Pump
35-58	Wetwell Agitation System	34-58	Wetwell Agitation System
35-59	Site Fencing	34-59	Site Fencing
35-60	Progress Energy's Transformer	34-60	Progress Energy's Transformer
35-61	Progress Energy's Power Feed	34-61	Progress Energy's Power Feed
35-62	Pump Hoist and Trolley System	34-62	Pump Hoist and Trolley System
35-63	HVAC System	34-63	HVAC System
35-64	Intrusion Alarm	34-64	Intrusion Alarm
P-1	20" FM PS via Oleander to Greenville Loop Rd		
P-2	20" FM along Greenville Loop Road		
P-3	20" FM under Hewletts Ck		
P-4	20" SS upstream of PS 34		
P-5	ARV Assemblies on 20" FM		
P-6	24" FM from PS to Cascade Dr		
P-7	24" FM from Cascade Dr to College Rd		
P-8	24" FM from College Rd to Pine Valley		
P-9	24" FM from Pine Valley to Independence Blvd		
P-10	24" FM along Independence/River Rd to WWTP		
P-11	24" Mag Meter at WWTP		
P-12	ARV Assemblies on 24" FM		
P-13	Re-dosing Stations Chem Storage		
P-14	Re-dosing Stations Chem Feed Pump		
P-15	Re-dosing Stations Chem Feed Piping		

IMPORTANCE FOR PROPER OPERATION	CONSEQUENCE OF IMMEDIATE FAILURE: LOW (1)	CONSEQUENCE OF IMMEDIATE FAILURE: MODERATE (2)	CONSEQUENCE OF IMMEDIATE FAILURE: HIGH (3)
LOW (A)	35-5 Screenings Conveyor 35-7 Odor Control Filter 1 35-8 Odor Control Filter 2 35-9 Odor Control Blower 35-10 Odor Control Duct 35-11 Corrosion Control Chem Storage 35-12 Corrosion Control Feed Pump 35-13 Corrosion Control Feed Piping 35-14 Pump #1 Suction PV 35-15 Pump #1 Suction Piping 35-16 Pump #1 (2500 gpm) 35-17 Motor #1 (60 hp) 35-18 Pump #1 Discharge Piping 35-19 Pump #1 Discharge CV 35-20 Pump #1 Discharge PV 35-21 Pump #1 Elect. Drive 35-22 Pump #2 Suction PV 35-23 Pump #2 Suction Piping 35-24 Pump #2 (2500 gpm) 35-25 Motor #2 (50 hp) 35-26 Pump #2 Discharge Piping 35-27 Pump #2 Discharge CV 35-28 Pump #2 Discharge PV 35-29 Pump #2 Elect. Load Cell 35-57 Drywell Sump Pump 35-58 Wetwell Agitation System 35-59 Site Fencing 35-62 Pump Hoist and Trolley System 35-63 HVAC System 35-64 Intrusion Alarm P-13 Re-dosing Stations Chem Storage P-14 Re-dosing Stations Chem Feed Pump 34-5 Screenings Conveyor 34-7 Odor Control Filter 1 34-8 Odor Control Filter 2 34-9 Odor Control Blower 34-10 Odor Control Duct 34-11 Corrosion Control Chem Storage 34-12 Corrosion Control Feed Pump 34-13 Corrosion Control Feed Piping 34-14 Pump #1 Suction PV 34-15 Pump #1 Suction Piping 34-16 Pump #1 (3500 gpm) 34-17 Motor #1 (100 hp) 34-18 Pump #1 Discharge Piping 34-19 Pump #1 Discharge CV 34-20 Pump #1 Discharge PV 34-21 Pump #1 Elect. Load Cell 34-22 Pump #2 Suction PV 34-23 Pump #2 Suction Piping 34-24 Pump #2 (3500 gpm) 34-25 Motor #2 (100 hp) 34-26 Pump #2 Discharge Piping 34-27 Pump #2 Discharge CV 34-28 Pump #2 Discharge PV 34-29 Pump #2 Elect. Load Cell 34-57 Drywell Sump Pump 34-58 Wetwell Agitation System 34-59 Site Fencing 34-62 Pump Hoist and Trolley System 34-63 HVAC System 34-64 Intrusion Alarm P-15 Re-dosing Stations Chem Feed Piping	35-51 Generator (200 kW) 35-52 Generator Fuel Tank & Accessories 35-60 Progress Energy's Transformer 35-61 Progress Energy's Power Feed P-5 ARV Assemblies on 20" FM 34-51 Generator (450 kW) 34-52 Generator Fuel Tank & Accessories 34-60 Progress Energy's Transformer 34-61 Progress Energy's Power Feed P-12 ARV Assemblies on 24" FM	
MODERATE (B)	35-3 Barscreen Unit 1 35-4 Manual Bar Rack 35-55 High-High Level Float Control System 35-56 SCADA Panel P-11 24" Mag Meter at WWTP 34-3 Barscreen Unit 1 34-4 Barscreen Unit 2 34-55 High-High Level Float Control System 34-56 SCADA Panel	35-30 Pump #3 Suction PV 35-31 Pump #3 Suction Piping 35-32 Pump #3 (4300 gpm) 35-33 Motor #3 (125 hp) 35-34 Pump #3 Discharge Piping 35-35 Pump #3 Discharge CV 35-36 Pump #3 Discharge PV 35-37 Pump #3 Elect. Load Cell 35-48 Elect. Service Entrance 35-49 Elect. Main Circuit Panel 34-30 Pump #3 Suction PV 34-31 Pump #3 Suction Piping 34-32 Pump #3 (6000 gpm) 34-33 Motor #3 (300 hp) 34-34 Pump #3 Discharge Piping 34-35 Pump #3 Discharge CV 34-36 Pump #3 Discharge PV 34-37 Pump #3 Elect. Load Cell 34-48 Elect. Service Entrance 34-49 Elect. Main Circuit Panel	35-50 Automatic Transfer Switch
HIGH (C)		35-53 Pump Control Panel (Island Automation) 35-54 Pump Bubbler System 34-53 Pump Control Panel (Island Automation) 34-54 Pump Bubbler System	35-1 County Precast Vault 35-2 Influent Barscreen Structure 35-6 Pump Station Structure 35-38 Pump #4 Suction PV 35-39 Pump #4 Suction Piping 35-40 Pump #4 (4100 gpm) 35-41 Motor #4 (150 hp) 35-42 Pump #4 Discharge Piping 35-43 Pump #4 Discharge CV 35-44 Pump #4 Discharge PV 35-45 Pump #4 Elect. Soft Start 35-46 PS Common Header Piping 35-47 PS Common Header PV 34-50 Automatic Transfer Switch P-1 20" FM PS via Oleander to G'ville Loop Rc P-2 20" FM along Greenville Loop Road P-3 20" FM under Hewletts Ck P-4 20" SS upstream of PS 34 34-1 County FM Vault 34-2 Influent Barscreen Structure 34-6 Pump Station Structure 34-38 Pump #4 Suction PV 34-39 Pump #4 Suction Piping 34-40 Pump #4 (6600 gpm) 34-41 Motor #4 (400 hp) 34-42 Pump #4 Discharge Piping 34-43 Pump #4 Discharge CV 34-44 Pump #4 Discharge PV 34-45 Pump #4 Elect. Drive 34-46 PS Common Header Piping 34-47 PS Common Header PV P-6 24" FM from PS to Cascade Dr P-7 24" FM from Cascade Dr to College Rd P-8 24" FM from College Rd to Pine Valley P-9 24" FM from Pine Valley to Independence Blvd P-10 24" FM along Independence/River Rd to WWTP

				Failure Mode (3)					
ID	**Asset**	**Criticality Rating (1)**	**Type Category (2)**	**Capacity Limited**	**Level of Service**	**Consumptive Mortality**	**Efficiency Limited**	**Willful or Unwillful Intent**	**Comments**
34-45	Pump #4 Elect. Drive	3C	IV		X				
35-1	County Precast Vault	3C	III			X			in poor condition
P-2	20" FM PS via Oleander to Greenville Loop Rd	3C	III			X			
P-4	20" SS upstream of PS 34	3C	III			X			
35-38	Pump #4 Suction PV	3C	I			X			
35-39	Pump #4 Suction Piping	3C	I			X			
35-40	Pump #4 (4100 gpm)	3C	II	X					Failure mode based on Capacity TM
35-41	Motor #4 (150 hp)	3C	II	X					
35-42	Pump #4 Discharge Piping	3C	I	X					
35-43	Pump #4 Discharge CV	3C	I	X					
35-44	Pump #4 Discharge PV	3C	I	X					
35-45	Pump #4 Elect. Soft Start	3C	II	X					
34-38	Pump #4 Suction PV	3C	I			X			
34-39	Pump #4 Suction Piping	3C	I			X			
34-40	Pump #4 (6600 gpm)	3C	II	X					Not cap. limited w/ Alt #3 & #4 in TM#1
34-41	Motor #4 (400 hp)	3C	II	X					
34-42	Pump #4 Discharge Piping	3C	I	X					
34-43	Pump #4 Discharge CV	3C	I	X					
34-44	Pump #4 Discharge PV	3C	I	X					
34-46	PS Common Header Piping	3C	I	X					
34-47	PS Common Header PV	3C	I	X					
34-50	Automatic Transfer Switch	3C	II		X				no bypass with current ATS
P-1	20" FM PS via Oleander to Greenville Loop Rd	3C	I	X					along Wrightsville Beach Rd
P-3	20" FM under Hewletts Ck	3C	I	X					section under creek
P-6	24" FM from PS to Cascade Dr	3C	I	X					through swamp
P-7	24" FM from Cascade Dr to College Rd	3C	I	X					in neighborhood
P-8	24" FM from College Rd to Pine Valley	3C	I	X					mostly along Shipyard
P-9	24" FM from Pine Valley to Independence Blvd	3C	I	X					in neighborhood
P-10	24" FM along Independence/River Rd to WWTP	3C	I	X					
35-2	Influent Barscreen Structure	3C	I			X			
35-6	Pump Station Structure	3C	I			X			
35-46	PS Common Header Piping	3C	I			X			
35-47	PS Common Header PV	3C	I			X			group rated 1B TWH moved it to 3C
34-1	County FM Vault	3C	I			X			
34-2	Influent Barscreen Structure	3C	I			X			
34-6	Pump Station Structure	3C	I			X			
35-50	Automatic Transfer Switch	3B	II		X				higher than 34-50 b/c loose auto
35-53	Pump Control Panel (Island Automation)	2C	II			X			
35-54	Pump Bubbler System	2C	II			X			
34-53	Pump Control Panel (Island Automation)	2C	II			X			
34-54	Pump Bubbler System	2C	II			X			
35-37	Pump #3 Elect. Load Cell	2B	IV	X					
34-37	Pump #3 Elect. Load Cell	2B	IV		X				
35-30	Pump #3 Suction PV	2B	I			X			
35-31	Pump #3 Suction Piping	2B	I			X			
35-32	Pump #3 (4300 gpm)	2B	II	X					
35-33	Motor #3 (125 hp)	2B	II	X					
35-34	Pump #3 Discharge Piping	2B	I	X					
35-35	Pump #3 Discharge CV	2B	I	X					
35-36	Pump #3 Discharge PV	2B	I	X					
35-48	Elect. Service Entrance	2B	I			X			could re-feed
35-49	Elect. Main Circuit Panel	2B	I			X			could re-feed
34-30	Pump #3 Suction PV	2B	I			X			
34-31	Pump #3 Suction Piping	2B	I			X			
34-32	Pump #3 (6000 gpm)	2B	II	X					Not cap. limited w/ Alt #3 & #4 in TM#1
34-33	Motor #3 (300 hp)	2B	II	X					

ID	Asset	Criticality Rating (1)	Type Category (2)	Failure Mode (3)					Comments
				Capacity Limited	Level of Service	Consumptive Mortality	Efficiency Limited	Willful or Unwillful Intent	
34-34	Pump #3 Discharge Piping	2B	I	X					
34-35	Pump #3 Discharge CV	2B	I	X					
34-36	Pump #3 Discharge PV	2B	I	X					
34-48	Elect. Service Entrance	2B	I			X			could re-feed
34-49	Elect. Main Circuit Panel	2B	I	X					could re-feed
P-5	ARV Assemblies on 20" FM	2A	III			X			
P-12	ARV Assemblies on 24" FM	2A	III			X			
35-51	Generator (200 kW)	2A	II	X					
35-52	Generator Fuel Tank & Accessories	2A	II	X					
35-60	Progress Energy's Transformer	2A	I			X			
35-61	Progress Energy's Power Feed	2A	I			X			
34-51	Generator (450 kW)	2A	II	X					
34-52	Generator Fuel Tank & Accessories	2A	II	X					
34-60	Progress Energy's Transformer	2A	I			X			
34-61	Progress Energy's Power Feed	2A	I			X			
35-3	Barscreen Unit 1	1B	II			X			
35-4	Manual Bar Rack	1B	II			X			
35-55	High-High Level Float Control System	1B	II			X			
35-56	SCADA Panel	1B	II			X			
34-3	Barscreen Unit 1	1B	II			X			
34-4	Barscreen Unit 2	1B	II			X			
34-55	High-High Level Float Control System	1B	II			X			
34-56	SCADA Panel	1B	II			X			
P-11	24" Mag Meter at WWTP	1B	II			X			
35-29	Pump #2 Elect. Load Cell	1A	IV	X					
34-21	Pump #1 Elect. Load Cell	1A	IV	X					
34-29	Pump #2 Elect. Load Cell	1A	IV	X					
35-5	Screenings Conveyor	1A	II			X			
35-7	Odor Control Filter 1	1A	II			X			
35-8	Odor Control Filter 2	1A	II			X			
35-9	Odor Control Blower	1A	II			X			
35-10	Odor Control Duct	1A	I			X			
35-11	Corrosion Control Chem Storage	1A	I			X			
35-12	Corrosion Control Feed Pump	1A	II			X			
35-13	Corrosion Control Feed Piping	1A	I			X			
35-14	Pump #1 Suction PV	1A	I			X			
35-15	Pump #1 Suction Piping	1A	I			X			
35-16	Pump #1 (2500 gpm)	1A	II	X					
35-17	Motor #1 (60 hp)	1A	II	X					
35-18	Pump #1 Discharge Piping	1A	I	X					
35-19	Pump #1 Discharge CV	1A	I	X					
35-20	Pump #1 Discharge PV	1A	I	X					
35-21	Pump #1 Elect. Drive	1A	IV	X					
35-22	Pump #2 Suction PV	1A	I			X			
35-23	Pump #2 Suction Piping	1A	I			X			
35-24	Pump #2 (2500 gpm)	1A	II	X					
35-25	Motor #2 (50 hp)	1A	II	X					
35-26	Pump #2 Discharge Piping	1A	I	X					
35-27	Pump #2 Discharge CV	1A	I	X					
35-28	Pump #2 Discharge PV	1A	I	X					
35-57	Drywell Sump Pump	1A	II			X			
35-58	Wetwell Agitation System	1A	II			X			
35-62	Pump Hoist and Trolley System	1A	II			X			
35-63	HVAC System	1A	II			X			
35-64	Intrusion Alarm	1A	II			X			
34-5	Screenings Conveyor	1A	II			X			
34-7	Odor Control Filter 1	1A	II			X			
34-8	Odor Control Filter 2	1A	II			X			
34-9	Odor Control Blower	1A	II			X			
34-10	Odor Control Duct	1A	I			X			

ID	Asset	Criticality Rating (1)	Type Category (2)	Failure Mode (3)					Comments
				Capacity Limited	Level of Service	Consumptive Mortality	Efficiency Limited	Willful or Unwillful Intent	
34-11	Corrosion Control Chem Storage	1A	I			X			
34-12	Corrosion Control Feed Pump	1A	II			X			
34-13	Corrosion Control Feed Piping	1A	I			X			
34-14	Pump #1 Suction PV	1A	I			X			
34-15	Pump #1 Suction Piping	1A	I			X			
34-16	Pump #1 (3500 gpm)	1A	II	X					
34-17	Motor #1 (100 hp)	1A	II	X					
34-18	Pump #1 Discharge Piping	1A	I	X					
34-19	Pump #1 Discharge CV	1A	I	X					
34-20	Pump #1 Discharge PV	1A	I	X					
34-22	Pump #2 Suction PV	1A	I			X			
34-23	Pump #2 Suction Piping	1A	I			X			
34-24	Pump #2 (3500 gpm)	1A	II	X					
34-25	Motor #2 (100 hp)	1A	II	X					
34-26	Pump #2 Discharge Piping	1A	I	X					
34-27	Pump #2 Discharge CV	1A	I	X					
34-28	Pump #2 Discharge PV	1A	I	X					
34-57	Drywell Sump Pump	1A	I			X			
34-58	Wetwell Agitation System	1A	II			X			
34-62	Pump Hoist and Trolley System	1A	II			X			
34-63	HVAC System	1A	II			X			
34-64	Intrusion Alarm	1A	II			X			
P-13	Re-dosing Stations Chem Storage	1A	I			X			
P-14	Re-dosing Stations Chem Feed Pump	1A	II			X			
P-15	Re-dosing Stations Chem Feed Piping	1A	I			X			
35-59	Site Fencing	1A	I			X			
34-59	Site Fencing	1A	I			X			

Notes:

1. Criticality Rating: Consequence of Immediate Failure (1 = Low, 2 = Moderate, 3 = High), Importance for proper operation (A = Low, B = Moderate, C = High)
2. Asset Type Code: I = structural/static component, no known deficiencies; II = mechanical or control component, no known deficiencies; III = strucutal/static component, known deficiencies; IV = mechanical or control component, known deficiencies. Note: Detailed asset condition assessments were not performed because pump stations are about to undergo a significant electrical upgrade with miscellaneous other improvements.
3. Mode of failure noted is the "most likely" mode of failure. Focus of rating is to separate O&M assets from assets that will require redesign or replacement. The "Willful or Unwillful Intent" category includes vandalism, operator error, and natural disaster.

Table TM 5.4 – "Consequence Factor 3" Asset Evaluation Summary

Asset Group	Function	Meets Objectives?	Evaluation Recommendations
PS 35 Pump #4 Electrical Drive (34-45)	Mechanical and control equipment that provides variable speed control of pump #4.	No	The Robicon drive's dated technology makes maintenance difficult and there is a long lead-time on parts. **Drive spare parts should be kept on hand until replacement drive is installed.** *(replacement drive is included in the City's PS 34 & PS 35 Improvements project)*
PS 35 County Pre-cast Vault (35-1)	Static structure that serves as a junction box for County wastewater flows from several pressure and gravity pipelines.	No	Structure shows severe signs of corrosion. **Replace or rehabilitated immediately**.
20" FM along Greenville Loop Road (P-2)	20" force main	No	DIRP field testing indicates the need to **replace a 500 LF section of the force main near Shinnwood Road**. Details of the condition assessment are included in Technical Memo #4 (TM #4).
20" SS upstream of PS 34 (P-4)	20" gravity sewer	No	Field observations and CCTV video indicate the need to **replace the gravity sewer that connects the 20" FM to PS 34**. Details of the condition assessment are included in TM #3. Routing alternatives of this pipeline are being reviewed for this work.
PS 35 Pump #4 and related piping (35-38 through 35-45)	Pump #4 is the largest pump in the station (4100 gpm, 150 hp).	No	The capacity evaluation (TM #1) identified that the potential flows to PS 35 exceed its design capacity with the current service area. The firm pumping capacity of this station needs to be upgraded. **Existing service areas should be re-directed to provide temporary flow relief. The pump station should be expanded to handle peak build-out flows with redundant pumping capacity.**
PS 34 Pump #4 and related piping (34-38 through 34-44)	Pump #4 is the largest pump in the station (6600 gpm, 400 hp).	Depends on selected FM and service area alternative selected	TM #1 documents that the pump station has operated in excess of its current design capacity for the current service area. Depending on the re-routing of contributing flows and new force main alternative selected, the pump capacities may need to be upgraded. **Existing service areas should be re-directed to provide temporary flow relief. Evaluate redundant pumping capacity upon selection of the force main and service area alternative selected.**

PS 34 Common Header Piping and Isolation Plug Valve (34-46, 34-47)	The header is located in the PS drywell. All four pump discharge to the common header. The plug valve provides flow isolation from within the drywell. There is an additional isolation plug valve in the pump station yard.	Depends on selected FM and service area alternative selected	Since there is no back-up header, this header is highly critical for normal operation; however, it is a static structure and readily accessible for regular inspection. *There will be an opportunity to inspect part of the header piping and the discharge piping from pumps #1 and #2 when these elements are removed in the City's PS 34 & PS 35 Improvements project.* **The header should be monitored for leaks and periodically checked by non destructive testing for integrity loss due to corrosion and erosion.**
PS 34 and PS 35 Automatic Transfer Switch (34-50, 35-50)	The ATS serves to automatically transfer the station electrical loads from utility power to generator power upon loss of utility power. ATS status is reported to the SCADA system for remote annunciation. The ATS is not of the type that has an isolated by-pass for use in the case of lost ATS electronics.	No	Staff reports that if ATS were to fail, there are plans in place to install jumpers around the ATS. **With the limited response time available, an ATS with isolated bypass should be installed to provide quicker response to a switch failure.**
Force Mains (P-1, P-3, and P-6 through P-10)	20" and 24" force main (except P-2 section discussed above). Pipelines are typically treated as a static system with the industry standard being a single force main system without on-line redundancy. However, there are a number of factors with the NEI force main that should be considered including: The force main is long (49,000 LF), it traverses across and under several high-profile and environmentally sensitive waters, it traverses along several high-traffic roads, and it has a history of pipeline failures.	No	Since the force main is projected to be under-capacity a decision will need to be made whether to install a large force main and abandon the existing line or to size a new force main to operation in parallel with the existing rehabilitated force main. Since the force main is highly critical in meeting the primary goal of the NEI system, having a parallel piping system, even if full backup capacity is not provided, would improve the operational reliability of the NEI. The extent of and feasibility of rehabilitation is discussed in the Deficiency Identification and Repair Program technical memorandum (TM #4). **Install a new parallel force main system such that the combined force mains system can accommodate build-out peak flows. Upon completion of the new force main, rehabilitate the existing force main.** **Install a flow meter on the PS 34 discharge force main and on new long force main sections that are not manifolds for other pump stations, and prepare automatic accountability of flow routines to annunciate an alarm if "flow in" does not equal "flow out", within tolerances.**

PS 34 and PS 35 Bar screen Structures (34-2 and 35-2)	The bar screen structure is a concrete structure that houses the bar screens and abandoned grit removal chamber. Wastewater still passes through the grit removal chamber, but there is no grit removal treatment provided. There is no piping by-pass around the structure.	Yes	**A condition assessment of the structure should be performed and repeated periodically to assure reliable operation of the structure and to monitor its consumptive mortality.**
PS 34 and PS 35 Pump Station Structures (34-6 and 35-6)	The pump station structure includes a concrete wetwell, concrete drywell, and a masonry structure with a built-up roof.	Yes	The City has plans underway to re-roof the both pump station structures. **A condition assessment of the structure should be performed and repeated periodically to assure reliable operation of the structure and to monitor its consumptive mortality.**
PS 35 Common Header Piping and Isolation Plug Valve (35-46 and 35-47)	The header is located in the PS drywell. All four pump discharge to the common header. The plug valve provides flow isolation from within the drywell. There is an additional isolation plug valve in the pump station yard.	Yes	Since there is no back-up header, this header is highly critical for normal operation; however, it is a static structure and readily accessible for regular inspection. *There will be an opportunity to inspect the header piping and the discharge piping when these elements are removed in the City's PS 34 & PS 35 Improvements project for installation of a flow meter.* **The header should be monitored for leaks and periodically checked by non destructive testing for integrity loss due to corrosion and erosion.** The header will be capacity limited with the projected flows. It is projected that the flow expansion project would reconfigure the pump station with a second discharge header.
PS 34 County FM Vault (34-1):	At pump station 34, the county junction vault serves to combine flows from several sources. Influent piping has been added to PS 34 over the years created a hodge-podge of piping.	Yes	As part of the gravity sewer modifications on the 20" force main just upstream of PS 34, the influent piping will be revised to reduce turbulence and to create a more efficient piping layout. **As part of this work the county vault will be abandoned.**

Table TM 5.5 – "Consequence Factor 2" Asset Evaluation Summary

Asset Group	Function	Meets Objectives?	Evaluation Recommendations
PS 34 and PS 35 Pump Control Panel and Bubbler Systems (34-53, 34-54, 35-53, and 35-54):	The bubbler system detects wetwell level and sends a depth signal to the Island Automation pump control panel at each pump station. The pump control panel performs logic operations to sequence pumps and to call for changes in pump speeds based on various wetwell levels.	No	The bubbler system is backed up with a limited float system. In addition, the Pump Control Plan is backed up with SCADA pump controls. The back-up float controls do not provide adequate pump control and manual operation would likely be required if the bubbler system level detection was lost. *The City's PS 34 & PS 35 project will upgrade the float system and replace the bubbler system with an ultrasonic level control level detection system. Pump control will be converted to primary control via SCADA and the Island Automation control system will be replaced with logic controls built into the VFD drives.*
PS 34 and PS 35 Pump #3 Load Cells (34-37, 35-37):	At both pump stations, pump #3 is driven by a Flow Matcher load cell. The variable resistance load cell controls the speed at which the pump operates.	No	The Flow Matcher load cell technology makes maintenance difficult and there is a long lead-time on parts. **Drive spare parts should be kept on hand until replacement drive is installed.** *(replacement drive is included in the City's PS 34 & PS 35 Improvements project)*
PS 35 Pump #3 and related piping (35-30 through 35-36)	Pump #3 is the 2nd largest pump at this station (4300 gpm, 125 hp). Although its nameplate flowrate is higher than pump #4 it operates at a slightly lower rate. The capacity of this pump sets the current firm capacity of the pump station.	Yes	In the event of failure, pump #4 can provide redundant service.
PS 34 and PS 35 Electrical Service Entrance and Main Circuit Panel (35-48, 35-49, 34-48, and 34-49)	The service entrance is the utility power feed from Progress Energy. The main circuit panel (MCP) is the central electrical panel that feed the pump drives and other electrical devices in the pump stations.	No @ PS 34; Maybe at PS 35 depending on service area alternative selected.	The service entrance and MCP meets the criticality goals. The generator provides redundant power supply to the utility service entrance. If the MCP were to suffer catastrophic failure, the City has a plan to install jumpers around the panel. **Up-size service entrances with pump capacity improvements.**
PS 34 Pump #3 and related piping (34-30 through 34-36)	Pump #3 is the 2nd largest pump at this station (6000 gpm, 300 hp). The capacity of this pump sets the current firm capacity of the pump station.	Yes	Pump #3 is the primary duty pump at this station. In the event of failure, pump #4 could provide redundant service.

FM Air Release Valve (ARV) Assemblies (P-5 and P-12)	The FM air release valves are located primarily at high points along the FM route. The current valves are pressure relief (not combination air and vacuum valves) and they are located in CMU masonry vaults. The ARV's allow air to be expelled from the force main to maintain full-pipe flow and to expel corrosive gases.	No	The Surge Analysis technical memo (TM #3) indicates that these valves are in poor condition. **They should be replaced combination air/vacuum valves to control pipeline surge pressures.**
PS 34 and PS 35 Generator, Fuel Tank, and Accessories (34-51, 34-52, 35-51, and 35-52	The generator and related accessories at each station provide stand-by power to the station in the case of utility power disruption. The generators are housed in masonry structures. The fuel tanks are above grade tanks located outside, but within the fenced area.	Depends on selected FM and service area alternative selected	The generator at PS 35 will not be large enough to start and run the pump station when the pumps are upgraded. Staff reports that the generator provides adequate starting and operation of the largest pump. **Generator replacement should be included with the project to upgrade the pump station capacity.** Staff reports that the generator provides adequate starting and operation of the largest pump. **The generator at PS 35 may be capacity limited depending on the selected FM and service area alternative selected.**
PS 34 and PS 35 Progress Energy's Transformer and Power Feed (34-60, 34-61, 35-60, and 35-61	The pole mounted transformers and overhead utility power feed are owned by Progress Energy. The transformers at PS 34 are located in wooded utility right of way outside the fenced area. The transformers at PS 35 are located outside the fenced site behind a traffic guard rail.	Yes, with easement clearing	**The utility right of way at PS 34 should be cleared and maintained to reduce the potential for power loss from nearby falling trees.**

APPENDIX A

Criticality Workshop
Introduction

Northeast Interceptor Improvements

City of Wilmington, NC

Criticality Assessment Workshop

Kimley-Horn and Associates, Inc.

HIGHFILL Infrastructure Engineering, P.C.

Outline

- 4 Parallel Processes
  - Deficiency Identification and Repair Program (Condition Assessment)
  - System Operation Evaluation
  - Capacity Analysis
  - Criticality Assessment
- Preliminary Engineering Report

Northeast Interceptor Improvements

System Reliability Evaluation

1. What are the key assets?
2. What is the criticality of each asset?
3. What risk levels are acceptable (Business Risk Level)?
4. How can these assets fail and what preventative measures are available?
   – Long-term/chronic
   – Immediate/acute
5. What to fix first?

Northeast Interceptor Improvements

Definitions/Assumptions

- Key asset: piece (or group) of equipment, structure, or material important to the proper operation of the NEI system
- Proper operation: capable of meeting the required level of service
- Required level of service: performance that meets the requirements of it’s stakeholders, customers and regulators while doing so at a cost tolerable to the customers

Northeast Interceptor Improvements

Asset List (Step 1)

- Preliminary list prepared
  - Expand/Combine items if needed
- Systems are aggregated when applicable
- Minor assets are *not* included

Criticality Matrix (Step 2)

		Consequence of Immediate Failure		
		LOW (1)	MOD. (2)	HIGH (3)
Importance for Proper Operation	LOW (A)			
	MODERATE (B)			
	HIGH (C)			

Northeast Interceptor Improvements

Business Risk Level (Step 3)

- What level of risk is acceptable?
  - Use criticality matrix to determine risk tolerance boundary
- Review assets near boundary to confirm category
- Possible risk response levels:
  - On-line, connected redundancy
  - Alternate systems with limited capacity
  - Replacement items in storage with response planning
  - Run to failure and replace

Northeast Interceptor Improvements

Modes of Failure & Prevention (Step 4)

- How will critical assets likely fail
- Review alternatives for
  - Increased maintenance vs. run to failure
  - Off-line redundancy (i.e. storage)
  - On-line redundancy
  - Monitoring to anticipate failure
  - Remote indications of failure (reduce response time)

Prioritize Improvements (Step 5)

- Level of criticality
- Cost
- Time to implement
- Coordination with operations evaluation, capacity analysis, and DIRP
- Potential for increased reliability… GOAL!